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Indian Standard

TIN OR TIN-LEAD COATED COPPER WIRE — SPECIFICATION

(First Revision)

ICS 25.220.40; 77.150.30; 29.060.10

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

June 2001

Price Group 4

Wires, Cables, Waveguides and Accessories Sectional Committee, LTD 18

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Wires, Cables, Waveguides and Accessories Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

This standard was originally published in 1980. It is now being revised to align it with the latest technological development. While revising this standard, assistance has been derived from ASTM B33-1(1985) and ASTM B189 (1985). There is no IEC standard on this subject.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

TIN OR TIN-LEAD COATED COPPER WIRE — SPECIFICATION

(First Revision)

1 SCOPE

This standard specifies requirements for tin and tin-lead coated copper wire having a nominal diameter (coated) within the range 0.08 mm to 2.0 mm.

2 REFERENCES

The following standards contain provisions which through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
26 : 1992	Tin ingot (*fourth revision*)
482 : 1991	Reels for covered, round electrical winding wires (*third revision*)
1885 (Part 32) : 1993	Electrotechnical Vocabulary: Part 32 Electric cables (*first revision*)
9000 (Part 3/ Sec 1 to 5) : 1977	Basic Environmental Testing Procedures for electronics and electrical items: Part 3 Dry heat test
9000 (Part 18/ Sec 1 to 3) : 1981	Basic environmental testing procedures for electronics and electrical items: Part 18 solderability test

3 TERMINOLOGY

3.1 For the purpose of this standard, the following definition in addition to those given in IS 1885 (Part 32) shall apply.

3.2 Tin or Tin-Lead Coated Copper Wire — A solid conductor of circular section having a uniform coating of tin or tin-lead alloy.

NOTE — For simplicity, the term 'wire' is used in this standard to indicate tin or tin-lead coated copper wire.

4 MATERIAL AND CONSTRUCTIONS

4.1 Material

The basic conductor of the coated wire shall be produced from high conductivity annealed copper.

NOTE — The physical constants of copper material are given in Annex A.

4.2 Resistivity

The resistivity at 20°C of the plain annealed copper wire before coating shall not exceed 0.017 241 ohm.mm^2/m.

4.3 Details of Coating

The copper wire shall be covered with a smooth, uniform, continuous and adherent layer of tin or tin-lead alloy.

4.3.1 *Tin*

Tin shall be of grade 99.75 (*see* IS 26).

4.3.2 *Tin-Lead Alloy*

Tin-lead alloy shall be non-antimonial Eutectic 63% tin 37% lead nominal alloy. Tin content shall be maintained at 63 ± 5% tin.

4.4 Diameter of Coated Wire

The finished coated wire diameter shall have a tolerance of +3% – 1% on the nominal specified diameter. The preferred nominal diameters of the coated wire are given in Table 1.

Table 1 Diameters And Resistance of Preferred Sizes of Wires

(*Clauses* 4.4, 6.3.1 *and* 6.4.1)

Preferred Diameter(Coated) Nominal mm (1)		Resistance (Coated) Maximum ohm/km (2)
0.08	$Res = 23.6/d^2$	3 687.5
0.1		2 360
0.15		1 049
0.2		590
0.25		377.6
0.3		259.94
0.4	$Res = 23.35/d^2$	145.94
0.5		93.40
0.6		63.5
0.7	$Res = 22.86/d^2$	46.65
0.8		35.72
1.0		22.86
1.2		15.87
1.6		8.93
2.0		5.715

5 PACKING AND MARKING

5.1 Packing

The wire shall be supplied on reels or coils, suitably packed and labelled.

5.1.1 When wire is supplied on reels, the reels shall conform to IS 482.

5.2 Marking

The label which shall be securely attached to the reel or coil shall contain the following information:

a) Manufacturer's name or trade-mark;
b) Nominal diameter of coated wire;
c) Type of wire (that is, tin coated or tin-lead coated);
d) Nominal composition of tin-lead alloy, in case of tin-lead alloy coated wire;
e) Mass (net and gross);
f) Country of manufacture; and
g) Any other information agreed to between the purchaser and the manufacturer.

5.2.1 The label may also be marked with the Standard Mark.

5.2.1.1 The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act*, 1986 and the Rules and Regulations made thereunder. Details of conditions under which a license for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

6 TESTS

6.1 Classification of Tests

6.1.1 *Type Tests*

The following shall constitute the type tests:

a) Measurement of diameter (*see* **6.4.1**),
b) Resistance test (*see* **6.3.1**),
c) Elongation and breaking strength test (*see* **6.4.2**),
d) Bend test (*see* **6.4.3**),
e) Solderability test (*see* **6.4.4**),
f) Continuity of coating test (*see* **6.4.5**), and
g) Adherence of coating test (*see* **6.4.6**).

6.1.1.1 *Number of samples*

For type tests, samples of suitable lengths shall be taken from 5 reels/coils each containing one continuous length of the given type of wire.

These reels/coils shall be selected at random from regular production lots so as to be representative as possible of the type under consideration. Each reel/coil shall be subjected to all the tests specified in **6.1.1**.

In the event of any one of the reels/coils failing to comply with the requirements if any respect; a further set of 5 reels/coils shall be taken all of which shall be again subjected to all the tests specified in **6.1.1**. If no single failure occurs, the type shall be considered as approved.

6.1.2 *Acceptance Tests*

The following shall constitute the acceptance tests:

a) Measurement of diameter (*see* **6.4.1**),
b) Resistance test (*see* **6.3.1**),
c) Elongation and breaking strength test (*see* **6.4.2**),
d) Solderability test (*see* **6.4.4**),
e) Continuity of coating test (*see* **6.4.5**), and
f) Adherence of coating test (*see* **6.4.6**).

6.1.2.1 *Sampling plan*

A recommendatory sampling plan is given in Annex B.

6.1.3 *Routine Test*

The measurement of diameter (*see* **6.4.1**) shall constitute routine test.

6.2 Conditions for Tests

6.2.1 *Standard Atmospheric Conditions for Testing*
Unless otherwise specified, all tests shall be carried out under the standard atmospheric conditions given below:

Temperature	15 to 30°C
Relative humidity	45 to 75 percent
Air pressure	86 to 106 kPa

6.2.2 *Preconditioning*

All the electrical measurements shall be carried out after storing the wires at the temperature for a time sufficient for the whole of the wires to reach that temperature.

6.2.3 Samples of wire from each reel/coil for various tests shall be taken after discarding a length of wire of 1.5 m from each end.

6.3 Electrical Tests

6.3.1 *Resistance Test*

The electrical resistance of the coated wire shall be expressed as the dc resistance in ohm/km at 20°C. The method used shall have an accuracy of 0.5 percent.

If resistance is measured at a temperature other than 20°C, the resistance shall be corrected to the reference temperature of 20°C by multiplying the measured value by the factor k, where:

$$k = \frac{1}{1 + 0.003\,93(t - 20)}$$

t being the temperature in °C at which measurement is made.

NOTE — For correction, reference may be made to Table 2. The correction factors have been arrived at on the basis of the formula mentioned above.

When measured by the above method, the resistance of the wire at 20°C shall not exceed the values specified in Table 1.

Table 2 Temperature Correction Factors

(*Clause* 6.3.1, Note)

Temperature, °C (1)	Correction Factor (2)	Reciprocal of Factor (3)
5	1.062 6	0.941 1
5.5	1.060 4	0.943 0
6	1.058 2	0.945 0
6.5	1.056 0	0.946 9
7	1.053 8	0.948 9
7.5	1.051 7	0.950 9
8	1.049 5	0.952 8
8.5	1.047 3	0.954 8
9	1.045 2	0.956 8
9.5	1.043 0	0.958 7
10	1.040 9	0.960 7
10.5	1.038 8	0.962 7
11	1.036 7	0.964 6
11.5	1.034 6	0.966 6
12	1.032 5	0.968 6
12.5	1.030 4	0.970 5
13	1.028 3	0.972 5
13.5	1.026 3	0.974 5
14	1.024 1	0.976 4
14.5	1.022 1	0.978 4
15	1.020 0	0.980 4
15.5	1.018 0	0.982 3
16	1.016 0	0.984 3
16.5	1.013 9	0.986 2
17	1.011 9	0.988 2
17.5	1.009 9	0.990 2
18	1.007 9	0.992 1
18.5	1.005 9	0.994 1
19	1.003 9	0.996 0
19.5	1.002 0	0.998 0
20	1.000 0	1.000 0
20.5	0.998 0	1.002 0
21	0.996 1	1.003 9
21.5	0.994 1	1.005 9
22	0.992 2	1.007 9
22.5	0.990 3	1.009 8
23	0.988 3	1.011 8
23.5	0.986 4	1.013 8
24	0.984 5	1.015 7
24.5	0.982 6	1.017 7
25	0.980 7	1.019 7
25.5	0.978 8	1.021 3
26	0.977 0	1.023 6
26.5	0.975 1	1.025 5
27	0.973 2	1.027 5
27.5	0.971 4	1.029 5
28	0.969 5	1.031 4
28.5	0.967 7	1.033 4
29	0.965 8	1.035 4
29.5	0.964 0	1.037 3
30	0.962 2	1.039 3

NOTES

1 Given the resistance of wire at t°C, the resistance at 20°C is found by multiplying the resistance at t°C by the factor for t°C given in col 2. Conversely, given the resistance at 20°C the corresponding resistance at t°C is found by multiplying the resistance at 20°C by the factor given in col 3.

2 The temperature coefficient of resistance of copper varies slightly from sample to sample according to its exact conductivity. Figures given above are based on the international standard coefficient of 0.003 93/°C at 20°C. The error in using this table for copper within the range of conductivity 99 percent to 101 percent shall not exceed 0.06 percent.

6.4 Mechanical Tests

6.4.1 *Measurement of Diameter*

The measurement of coated wire diameter shall be made with an accuracy better than 0.001 mm. If a micrometer is used it shall be ensured that the measuring force is in the range of 0.75 to 1.25 N. The spindle and the anvil of the micrometer shall have a diameter of 5 to 8 mm.

The diameter shall be measured at 60° angular displacement around the circumference of the wire at each of two places 1 m apart. The average of the six results shall be taken as the coated wire diameter.The measured value shall be within the limits specified in Table 1.

6.4.2 *Elongation and Breaking Strength Test*

The test shall be carried out after the test specimens have been conditioned at a temperature of 25 ± 2°C for at least 10 hours. The test shall be started within 5 minutes after removing the specimens from the conditioning atmosphere.

The test specimens shall be placed in a tensile testing machine in such a way that the free length between the jaws is approximately 250 mm (that is distance between reference lines marked on the wire). The speed of the testing machine shall be about 100 mm/min. The elongation at break shall be determined by measuring the distance between two reference lines at the moment of rupture and then calculating the percentage elongation in relation to the distance measured before the test, provided the fracture occurs between the reference marks and not closer than 25 mm to either mark. If the fracture occurs outside these limits and if the required elongation is not obtained, the test shall be discarded and another test made. Elongation and breaking strength values shall be not less than the values specified in Table 3.

Table 3 Elongation and Breaking Strength of Coated Wire

Nominal Diameter of Coated Wire mm (1)	Elongation, *Min* Percent (2)	Breaking Strength *Min* N/mm^2 (3)
Up to and including 0.25	10	200
Above 0.25 and up to and including 0.5	15	200
Above 0.5	20	200

6.4.3 *Bend Test*

One end of the test piece shall be held between two supports of hardened steel which shall be rounded to a radius equal to the diameter of the wire under test. The protruding portion of the test piece shall be bent through 90° and then brought back to its original position. It shall then be bent in the same plane in the reverse direction and again returned to its original vertical position. This procedure will be repeated until failure occurs. One bend consists of bending the test piece through an angle of 90° and then returning it to its original vertical position.

The wire shall satisfy the following conditions:

Nominal Diameter (Coated)	*No. of Bends Before Failure, Min*
mm	
0.2 to 0.3 (both inclusive)	4
0.4 to 0.5 (- do -)	6
0.6 to 0.7 (- do -)	8
0.8 to 1.2 (- do -)	10
1.6 to 2.0 (- do -)	12

6.4.4 *Solderability Test*

The coated wire shall satisfy the requirements of solderability test when tested in accordance with IS 9000 (Part 18/Sec 1 to 3), both before and after accelerated ageing. Accelerated ageing shall be carried out as follows:

a) The wire shall be subjected to dry heat for 16 hours at 155° C [*see* IS 9000(Part 3/Sec 1 to 5)], and

b) On removal from the dry heat oven, the wire samples shall be allowed to cool to room temperature. They are then subjected to solderability testing.

6.4.4.1 If solder globule method is used, the coated wire shall satisfy the solderability requirements as given below:

Condition of Coated Wire	*Soldering Time, Max Seconds*
As received	1.5
After accelerated ageing	2.5

6.4.4.2 The coated wire shall also satisfy the requirements of dewetting test in accordance with IS 9000 (Part 18/Sec 1 to 3).

6.4.5 *Continuity of Coating Test*

The wire shall meet the requirements of continuity of coating, when tested by the hydrochloric acid - sodium polysulphide test described in Annex C.

6.4.6 *Adherence of Coating Test*

The wire shall meet the requirements of adherence of coating, when tested by the wrapping and immersion test described in Annex D.

ANNEX A

(*Clause* 4.1, Note)

INTERNATIONAL STANDARDS FOR COPPER

A-1 The following values adopted by the International Electrotechnical Commission (IEC publication No. 28) for standard annealed copper have been taken as standard for annealed high conductivity copper:

a) At a temperature of 20°C, the volume resistivity of standard copper is 1/58 = 0.017 241 ohm. mm^2/m. Copper which has a resistivity at 20°C of 1/58 (0.017 241 ohm. mm^2/m) is said to have a conductivity of 100 percent.

b) At a temperature of 20°C, the density of standard annealed copper is 8.89 g/cm^3 .

c) At a temperature of 20°C, the coefficient of linear expansion of standard copper is 0.000 017 / °C.

NOTE — The above value of the coefficient of linear expansion may be applied to annealed copper over a temperature range from 0 to 150° C.

d) At a temperature of 20° C, the coefficient of variation of resistance with temperature of standard annealed copper, measured between two potential points rigidly fixed to the wire, the metal being allowed to expand freely, is:

$$0.003\,93 = \frac{1}{254.45} /°C$$

e) As a consequence it follows from (a) and (b) that at a temperature of 20°C the mass resistivity of standard annealed copper is:

1/58 × 8.89 = 0.153 28 ohm. g/m^2.

ANNEX B

(*Clause* 6.1.2.1)

RECOMMENDED SAMPLING PLAN

B-1 LOT

In any consignment, all the reels or coils of tin or tin-lead coated copper wire of the same type, manufactured from the same materials under essentially similar conditions of production shall be grouped together to constitute a lot.

B-2 SCALE OF SAMPLING

For judging the conformity of a lot to the requirements of the specification tests shall be done for each lot separately. For this purpose the number of reels or coils to be selected at random from a lot shall be in accordance with col 1 and 2 of Table 4.

Table 4 Scale of Sampling And Permissible Number of Defectives

(*Clauses* B-2, B-3.1 *and* B-3.2)

Lot Size	For Diameter, Resistance and Solderability		For Elongation, Breaking Strength, Continuity of Coating and Adherence of Coating	
	Sample Size	Permissible No. of Defectives	Sample Size	Permissible No. of Defectives
(1)	(2)	(3)	(4)	(5)
Up to 300	13	0	8	0
301 to 500	20	0	13	0
501 to 1 000	32	1	20	0
1 001 to 3 000	50	2	25	1
3 001 and above	80	3	50	2

B-3 NUMBER OF TESTS AND CRITERIA FOR ACCEPTANCE

B-3.1 From each of the reels or coils selected according to col 2 of Table 4 suitable lengths of test samples shall be taken after discarding approximately 1.5 m of the wire from both ends. Each of these test samples shall be subjected to the measurement of diameter, resistance and solderability. The number of test samples not fulfilling the requirements of any of these tests shall be less than or equal to the corresponding permissible number given in col 3 of Table 4.

B-3.2 For the test for elongation, breaking strength, continuity of coating and adherence of coating the number of samples to be tested and the permissible number of defectives shall be in accordance with col 4 and 5 of Table 4.

NOTES

1 The test samples for the purpose of **B-3.2** may be chosen from the reels or coils already selected for the purpose of **B-3.1**.

2 If required, for continuity of coating and adherence of coating, separate wires may be taken from the reels or coils selected according to col 4 of Table 4.

ANNEX C

(*Clause* 6.4.5)

CONTINUITY OF COATING TEST

C-1 SPECIMENS

C-1.1 Length of Specimens

Test specimens shall have a length of about 15 cm. They shall be tagged or marked to correspond with the coil or reel from which they were cut.

C-1.2 Treatment of Specimens

The specimens shall be thoroughly cleaned by immersion in a suitable organic solvent such as benzene, ether or trichloroethylene for at least 3 min; then removed and wiped dry with a clean, soft cloth (*see* Caution). The specimens thus cleaned shall be kept wrapped in a clean, dry cloth until tested. That part of the specimen to be immersed in the test solution shall not be handled. Care shall be taken to avoid abrasion by the cut ends.

CAUTION—Consideration should be given to toxicity and flammability when selecting solvent cleaners.

C-2 SPECIAL SOLUTIONS REQUIRED

C-2.1 Hydrochloric Acid Solutionsp gr 1.088 Commercial hydrochloric acid (sp gr 1.12) shall be diluted with distilled water to a specific gravity of 1.088 measured at 15°C. A portion of hydrochloric acid solution having a volume of 180 ml shall be considered to be exhausted when the number of test specimens prescribed in Table 5 of length as indicated in **C-3** have been immersed in it for two cycles.

Table 5 Limiting Number of Test Specimens For Coating Tests

(*Clause* C-2.1)

Nominal Diameter (Coated) mm	Maximum Number of Specimens to be Tested for 2 Cycles in 180 ml or Acid Solution
(1)	(2)
From 0.08 and under 0.76	14
From 0.76 and under 0.97	12
From 0.97 and under 1.27	10
From 1.27 and under 2.16	6

C-2.2 Sodium Polysulphide Solution — sp gr 1.142 (*see* Note)

A concentrated solution shall be made by dissolving sodium sulphide *cp* crystals in distilled water until the solution is saturated at about 20°C and adding sufficient flowers of sulphur (in excess of 250 g/l of solution) to provide complete saturation, as shown by the presence in the solution of an excess of sulphur after the solution has been allowed to stand for at least 24 hours. The test solution shall be made by diluting a portion of the concentrated solution with distilled water to a specific gravity of 1.142 at 15°C. The sodium polysulphide test solution should have sufficient strength to blacken thoroughly a piece of clean uncoated copper wire in 5 seconds. A portion of the test solution used for testing samples shall not be considered to be exhausted until it fails to blacken a piece of clean copper as described above.

NOTE — It is important that the polysulphide solution be of proper composition and strength at the time of test. A solution which is not saturated with sulphur or which has been made from decomposed sodium sulphide crystals may give a false indication of failure. Therefore, the requirement that the solution be tested by observing its blackening effect on a bright copper wire is significant. Significant also is the requirement that the solution be saturated with sulphur by allowing the solution to stand at least 24 hours after preparation. Attention is called also to the necessary for the use of sodium sulphide which has not deteriorated through exposure to air; and if exposure has occurred, the crystals should be tested for purity.

C-3 PROCEDURE

C-3.1 Immersion of Specimens

Immerse a length of at least 11 cm from each of the clean specimens, in accordance with the following cycles, in test solutions maintained at a temperature between 15 and 20°C:

a) Immerse the specimen for 1 min in the hydrochloric acid solution described in **C-2.1**, wash, and wipe dry;

b) Immerse the specimen for 30 seconds in the sodium polysulphide solution described in **C-2.2**, wash, and wipe dry;

c) Immerse the specimen for 1 minute in the hydrochloric acid solution, wash, and dry; and

d) Immerse the specimen for 30 seconds in the sodium polysulphide solution, wash and wipe dry.

C-3.2 Washing Specimens

After each immersion, immediately wash the specimens thoroughly in clean water and wipe dry with a clean, soft cloth.

C-3.3 Examination of Specimens

After immersion and washing, examine the specimens to ascertain if copper exposed through openings in the coating has been blackened by action of the sodium polysulphide. The specimens shall be considered to have failed if, by such blackening, exposed copper is revealed. No attention shall be paid to blackening within 12.5 mm of the cut end.

NOTE — Ordinarily tests shall be carried out at room temperature. In case of dispute, tests shall be done at the temperatures specified (*see* **C-2** and **C-3**).

ANNEX D

(*Clause* 6.4.6)

ADHERENCE OF COATING TEST

D-1 SPECIMENS

D-1.1 Length of Specimens

Test specimens shall be approximately 30 cm in length and shall be tagged or marked to correspond with the coil or reel from which they are cut.

D-1.2 Treatment of Specimens

The specimens shall be thoroughly cleaned, if required, by immersion in a suitable organic solvent such as benzene, ether or trichloroethylene for at least 3 minutes, then removed and dried (*see* Caution). The specimens thus cleaned shall be kept wrapped in a clean dry cloth until tested. That part of the specimens to be immersed in the test solution shall not be handled. Care shall be taken to avoid abrasion of the surface to be subjected to test.

CAUTION — Consideration should be given to toxicity and flammability when selecting solvent cleaners.

D-2 PROCEDURE

D-2.1 Wrapping

Slowly wrap the test specimen in a suitable manner in an open helix around a polished mandrel having rounded ends and a diameter not to exceed four times the nominal diameter of the specimen. Take care not to stretch the specimen during the wrapping operation. The spacing of the consecutive turns shall be approximately equal to the diameter of the wire. For sizes 0.5 mm and smaller not more than six helical turns shall be used for the test, and for wires larger than 0.5 mm not more than three turns shall be used.

D-2.2 Immersion Test

Remove the helically wrapped portion of the test specimen from the mandrel and immerse completely in the sodium polysulphide solution (*see* **C-2.2**) for 30 seconds at the temperature prescribed in **C-3** (*see* Note under **C-3.3**). On removal from the sodium polysulphide solution, immediately rinse the specimen in clean water and remove the excess by shaking.

D-2.3 Examination of Specimens

Examine visually the outer peripheral surface of the helically wrapped portion of the specimen. For wires 0.5 mm and smaller, a magnification not greater than 3X may be used. Any cracking or parting of the coating in this area shown by blackening of the copper shall be the cause for rejection. A greyish appearance of the coating after immersion shall not constitute failure.

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Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards: Monthly Additions'.

This Indian Standard has been developed from Doc : No. LTD 18 (1898).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters :

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110 002
Telephones : 323 01 31, 323 33 75, 323 94 02

Telegrams : Manaksanstha
(Common to all offices)

Regional Offices :		Telephone
Central	: Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 110 002	323 76 17 323 38 41
Eastern	: 1/14 C.I.T. Scheme VII M, V. I. P. Road, Kankurgachi CALCUTTA 700 054	337 84 99, 337 85 61 337 86 26, 337 91 20
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Printed at Prabhat Offset Press , Darya Ganj, New Delhi-2